Orbit comparison for TOPEX/Poseidon mission between GFZ and GSFC

The GFZ orbit is referred to as GFZ in the following study
The GSFC orbit is referred to as SL_cci

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Introduction:

- We will observe and analyse the impact of the precise orbit computed by GFZ for climate applications. It will be referred to as “GFZ”.

- We will compare this orbit with the reference one in SL_cci products, computed by GSFC. It will be referred to as “SL_cci”.

- In order to determine the impact of the GFZ orbit in terms of climate applications and temporal scales, we will try in this study to indicate for each impact detected if it’s a positive (+) or a negative (-) impact:

  - Low impact
  - Significant impact
  - No impact detected
### Global Mean Sea Level

#### TOPEX/Poseidon

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**Global Mean Sea Level**

- **Long-term evolution (trend)**
  - Inter annual signals (> 1 year)
  - Annual and semi-annual signals

**Regional Mean Sea Level**

- **Long-term evolution (trend)**
  - Annual and semi-annual signals

**Mesoscale**

- Signals < 2 months

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**Low impact detected on Global Mean Sea Level trend**

\[0.14 \text{mm/yr trend difference on the Global MSL}\]

\[\Rightarrow \text{due to stronger and abnormal 58.77-day signals on GFZ orbit solutions (58.77-day signal).}\]

**Remarks**

- Temporal evolution of SLA mean calculated **globally**.
Global Mean Sea Level

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No impact detected on Inter annual Signals

⇒ The figure below shows the mean difference between the two orbits calculated globally by cycle.
⇒ It’s not easy to determine inter-annual signals due to the strong 58.77-day signals on the GFZ solution
### Global Mean Sea Level

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**Significant impact detected on Periodic Signals**

- The impact on annual signals is low (about 0.5mm)
- No impact detected on semi annual signals
- 2 mm impact on 58.77-day signal. This signal is known to be an error and is increased with GFZ.
Global Mean Sea Level

⇒ Upper left panel: Periodograms of SLA around 1 year
⇒ Lower left panel: Periodograms of SLA between 0-1 year
⇒ Lower right panel: Periodograms of SLA around 58.77-day
Mesoscale

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Strong impact detected on a short temporal scale (signals < 2 months):

⇒ Crossovers Variance Differences are generally positive (see figures on next slide) between 0 and 4 cm²: This means that the new GFZ orbit shows a strong degradation by comparison to the SL_cci orbit.

⇒ The map of SSH crossovers Variance Differences shows that these degradations are global.
Temporale évolution de la variance de la hauteur de surface de la mer à croisement entre deux orbites:
- Dégénérescence (entre 0 et 4 cm²) avec GFZ

Carte de la variance des différences de hauteur de surface de la mer à croisement entre les orbites GFZ et SL_cci (sur l'ensemble de la période):
- Dégénérescence significative (1.5 cm²) globalement.
## Regional Mean Sea Level

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### Global Mean Sea Level
- Long-term evolution (trend)
- Inter annual signals (>1 year)
- Annual and semi-annual Signals

### Regional Mean Sea Level
- Long-term evolution (trend)
- Annual and semi-annual Signals

### Mesoscale
- Signals < 2 months

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Low impact detected on Regional Mean Sea Level

⇒ We observe a strong impact (>1 mm/yr) on the regional trends. It is positive in the Atlantic and the Indian oceans; and negative elsewhere.
⇒ This signal is low, currently, no tool are available to show if this signal is an improvement or not.
Regional Mean Sea Level

⇒ Map of Sea Level Anomaly differences between two Orbits (over all the period)
### Regional Mean Sea Level

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**Low impact detected on Annual and Semi-Annual Signals**

⇒ Amplitudes differences reach 3mm or -3mm for annual and semi-annual signal (see figures on next slide).

⇒ These differences are small and it is not possible to determine which orbit is the best one for these scales.

⇒ However, the impact on the phases is significant as it reaches 10° (about 10 days of phase shift).
Regional Mean Sea Level

⇒ Map of Sea Level Anomaly differences **amplitude** for **annual signal**

⇒ Map of Sea Level Anomaly differences **amplitude** for **semi-annual signal**

SLA with GFZ amplitude – SLA with SL_cci amplitude : annual signal

SLA with GFZ amplitude – SLA with SL_cci amplitude : semi-annual signal
Regional Mean Sea Level

⇒ Map of Sea Level Anomaly differences phase for annual signal.

⇒ Map of Sea Level Anomaly differences phase for semi-annual signal.

To be noted a phase value equal to 30° corresponds to a period of one month.

SLA with GFZ phase – SLA with SL_cci phase: annual signal

SLA with GFZ phase – SLA with SL_cci phase: semi-annual signal
Regional statistics between orbits

⇒ Map of Mean differences between GFZ and SL_cci (whole TOPEX/Poseidon period)
On this map we observe a difference up to 5 mm below -50° latitude and in West Pacific Ocean. The differences between the orbits become negative, down to -5mm in the West Indian, Atlantic and East Pacific Oceans.

⇒ Map of Standard deviation of the differences between GFZ and SL_cci (whole TOPEX/Poseidon period)
On this map we observe strong differences (>1cm) in the West Pacific Ocean
Orbits comparison for TOPEX/Poseidon mission

To conclude:

- The orbit computed by GFZ shows performances strongly degraded by comparison to SL_cci (GSFC std09)

- The main impacts are on the long-term evolutions at regional scale and on the mesoscale and periodic signals:
  - Scores at crossovers show, SL_cci is better for the mesoscale signal over T/P Period.
  - The 58-day signal in GFZ orbit may be considered as an error
  - For the regional trends, the signal is lower than 1 mm/yr and currently no tools exist to show if it is an improvement or not

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